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ABSTRACT

This publication provides data on scientific and engineering (S/E) personnel employed in private industry, which employs about 75 percent of the total work force and over 60 percent of the work force of scientists and engineers. Information on the supply, training, employment, and other personal and professional characteristics of S/E personnel is provided, by detailed occupational field and industry. (CS)

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scientists, engineers, and technicians in private industry: 1978-80

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FOREWORD

The Nation's scientific and technical human resources represent prime assets in achieving a high degree of social and cultural development, economic growth, technological advancement, and national security. Wherever employed—industry, universities and colleges, government facilities, or nonprofit organizations—scientific and engineering (S/E) personnel have produced impacts disproportionately greater than their numbers.

In continuing recognition of the vital role played by this resource, the National Science Foundation (NSF) has attempted to ensure a flow of data on the supply, training, employment, and other personal and professional characteristics of scientists and engineers to government, industry, educators, and the general public. One major gap in the development of employment data has been the lack of detailed employment statistics for scientists, engineers, and technicians in private industry. This sector employs about 75 percent of the total work force and over 60 percent of the work force of scientists and engineers. Information about the dynamics of this sector (e.g., changes in industrial composition and, within industries, changes in the occupational distributions of employed workers) is necessary to provide an understanding of utilization patterns of scientific and technical personnel. Such information also aids in human resources analysis and planning since it provides benchmarks for projecting future occupational requirements. These requirements, in turn, influence the decisions of educational planners, employers, and individuals making career plans.

This report presents the findings of employment studies based on data from surveys conducted by the Bureau of Labor Statistics for NSF. It encompasses, for the first time, comprehensive and up-to-date employment estimates of scientists, engineers, and technicians by detailed occupational field and industry.

Charles E. Falk
Director, Division of Science
Resources Studies
Directorate for Scientific,
Technological, and International
Affairs

October 1980

acknowledgments

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Within the National Science Foundation, Joseph Cangialosi was responsible for the analysis of the statistical material developed by the Bureau of Labor Statistics and preparation of the final report, under the general direction of Joel L. Barries, Study Director, Utilization Studies Group, with overall guidance by Alan Fechter, Head, Scientific and Technical Personnel Studies Section.

contents

	Page
Highlights	1
Introduction	2
Trends in S/E Employment in Private Industry	3
Employment by Industry	5
Concentration and Technological Intensity	7
Employment by Occupation	9
Appendixes:	
A. Technical Notes	12
B. Statistical Tables	16

highlights

- Science and engineering (S/E) employment in private industry remained virtually unchanged between 1970 and 1980—2.1 million. A long-run decline in S/E employment in manufacturing industries was countered by steady growth of S/E employment in nonmanufacturing industries. Between 1978 and 1980, however, employment in manufacturing increased slightly.
- Employment of scientists, engineers, and technicians in private industry is concentrated in relatively few industries. Among the 17 industries surveyed, 4 accounted for over one-half of the scientist, engineer, and technician (SE&T) employment: miscellaneous services (primarily engineering and architectural services), electrical equipment manufacturing, machinery manufacturing, and business services (including commercial computer service firms).
- Reflecting more general tendencies toward a service economy, recent employment growth was more rapid in nonmanufacturing industries. Nonmanufacturing industries account for 41 percent of SE&T employment in 1980, but accounted for 60 percent of the SE&T employment growth between 1978 and 1980.
- Projections through the eighties suggest that nonmanufacturing activity will continue to grow at a more rapid rate than manufacturing activity. The major beneficiaries of these projected industrial trends are expected to be civil engineers, computer specialists, geologists, and geophysicists.
- Technologically intensive industries can be identified by the concentration of employment of scientists and engineers relative to an industry's total employment. On this basis, the most technologically intensive nonmanufacturing industry is the miscellaneous services industry. This industry includes firms providing engineering, architectural, and surveying services. In manufacturing, the most technologically intensive industries are petroleum refining and chemical and related products.
- Within manufacturing, the largest engineering specialties were electrical/electronic and mechanical engineering, reflecting the relative importance of the electrical equipment and machinery industries. Civil engineers were the largest engineering specialty in nonmanufacturing, reflecting the importance of the engineering and architectural services industry.
- Chemists were by far predominant among scientists in the manufacturing industries and computer specialists in the nonmanufacturing industries.
- Of the 2.1 million industrial scientists, engineers, and technicians in 1980, almost one-half were technicians. Of the remaining 1.1 million most (about 80 percent) were engineers.
- The ratio of scientists and engineers to technicians is an index of the "skill-intensity" of SE&T employment. This index varied widely among industries. On average, manufacturing industries tend to be more skill intensive than nonmanufacturing industries (1.25 vs. 0.92). Within these broad sets of industries, the index exceeded 2.0 in transportation equipment, crude petroleum and natural gas extraction, and petroleum refining.

introduction

A relative shift of resources out of primary activities, such as agriculture and mining, into tertiary activities, such as services, has been occurring in the United States and in other advanced industrial societies for a considerable period of time. This shift reflects such factors as changes in consumer demand, government policy, patterns of foreign trade, and technology. These changes also affect the employment demand for scientific and technical personnel and can result in redistribution of this demand by field, degree level, and type of work activity. Since a large proportion of the Nation's scientific and technical activities are undertaken by private industry, information on these activities in this sector of the economy is useful and important. The National Science Foundation has been supporting the collection of data on the employment of scientists, engineers, and technicians in industry by supplementing and using the Occupational Employment Survey conducted regularly by the Bureau of Labor Statistics.

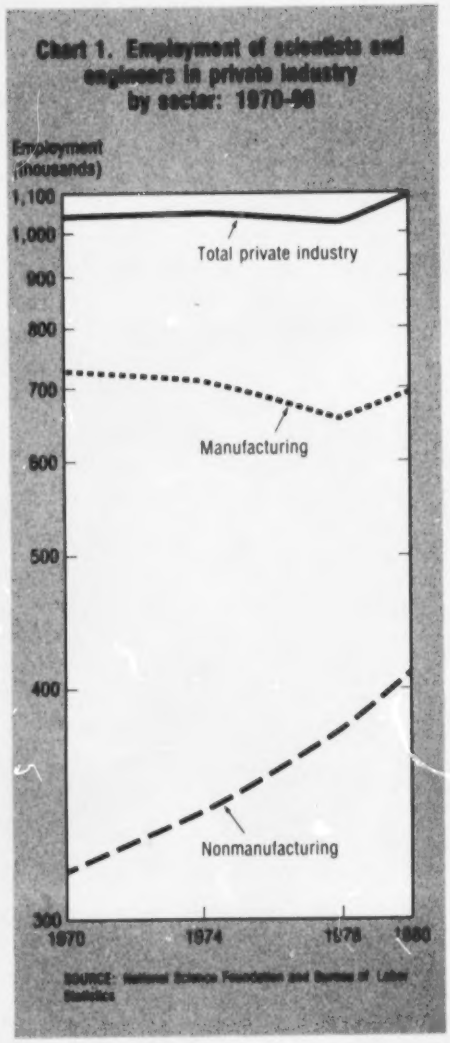
This report summarizes 1980 employment patterns and recent and expected trends in the industrial and occupational distribution of scientists, engineers, and technicians. The report explores pattern implications for future demands for scientific and technical personnel in various occupations. Results are limited to the manufacturing sector and largely to nonregulated industries in the nonmanufacturing sector (i.e., they exclude wholesale and retail trade, transportation, communications, and public utilities).

trends in s/e employment in private industry

The long-run trend in employment of scientists and engineers[1] in private industry has been flat over the 1970–80 period: 1.1 million in January 1980 compared to 1.0 million in 1970. Within the private industry sector, however, two distinct trends are apparent. In the manufacturing sector, the long-run trend has shown some decline, but in nonmanufacturing, it has shown steady growth (chart 1). Between 1970 and 1980, manufacturing employment of scientists and engineers fell at an average rate of about 1 percent per year until 1978, with a small recovery between 1978 and 1980 of 4 percent. Within manufacturing, most of the 1978–80 growth was accounted for by three industries—electrical equipment, machinery, and professional and scientific instruments. Growth in the nonmanufacturing sector, however, has been continuous over the 1970–80 period, increasing from 316,000 in 1970 to 413,000 or almost 3 percent per year. Between 1978 and 1980 estimated growth in nonmanufacturing was over 9 percent.[2] In nonmanufacturing, most of the growth occurred in miscellaneous services, business services, and crude petroleum and natural gas extraction (chart 2).

Because of the lack of growth in manufacturing between 1970 and 1980, employment in nonmanufacturing rose from 30 percent of total private industry S/E employment in 1970 to 37 percent by 1980.

By occupation, scientist employment increased at an average annual rate of about 4.7 percent over the 1970–80 decade, while engineering employment increased at an average annual rate of 2.2 percent. However, over the 1978–80 period, employment of scientists and engineers increased at roughly similar rates, about 3 percent per year.



[1] For definition of scientists, engineers, and technicians see the technical notes. Long-run trend data for technicians are not available.

[2] The 1970 estimates are from U.S. Department of Labor, Bureau of Labor Statistics, *Employment of Scientists and Engineers 1950–70*, Bulletin 1961 (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office, 1973). The comparable 1974 estimates are from unpublished data of BLS and the 1978–80 period represents comparable May 1978 and January 1980 estimates by NSF based on data of the BLS (technical notes).

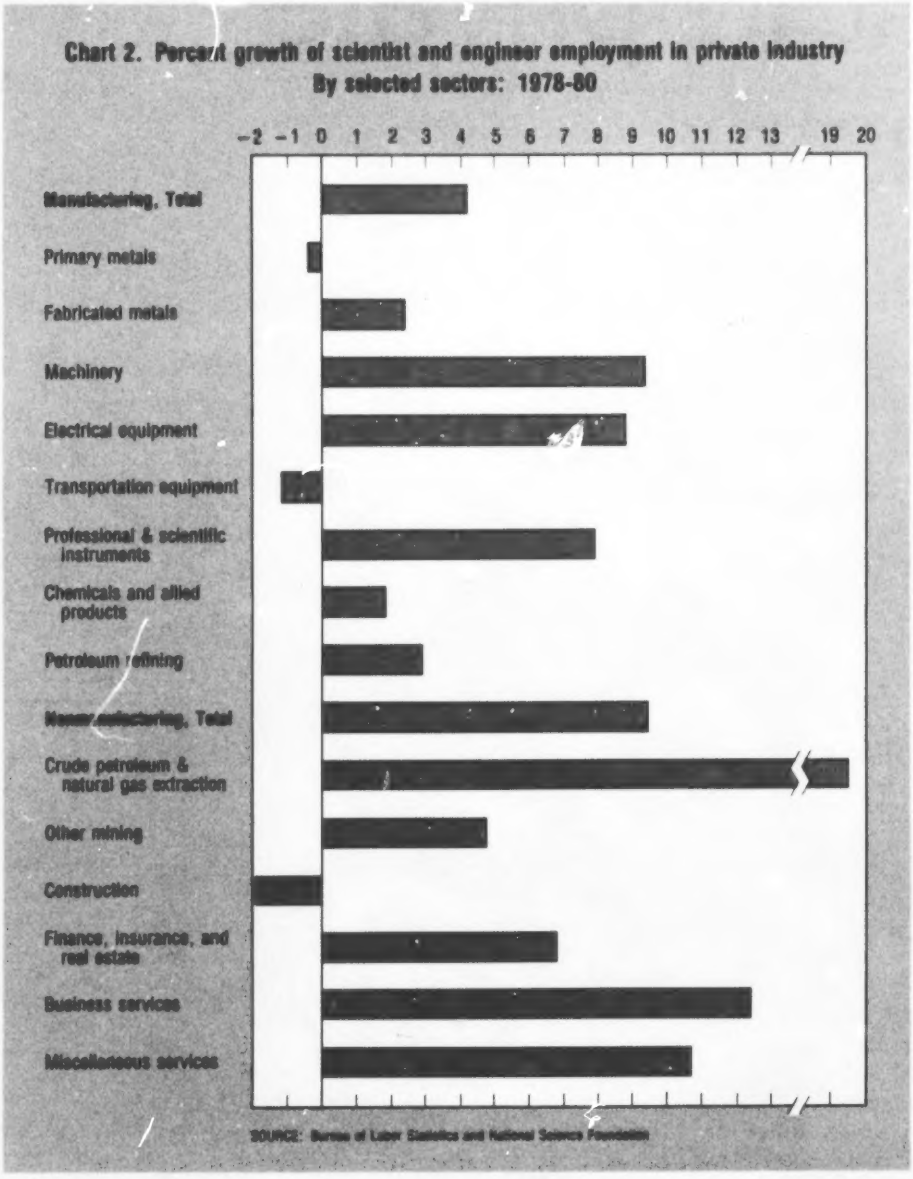
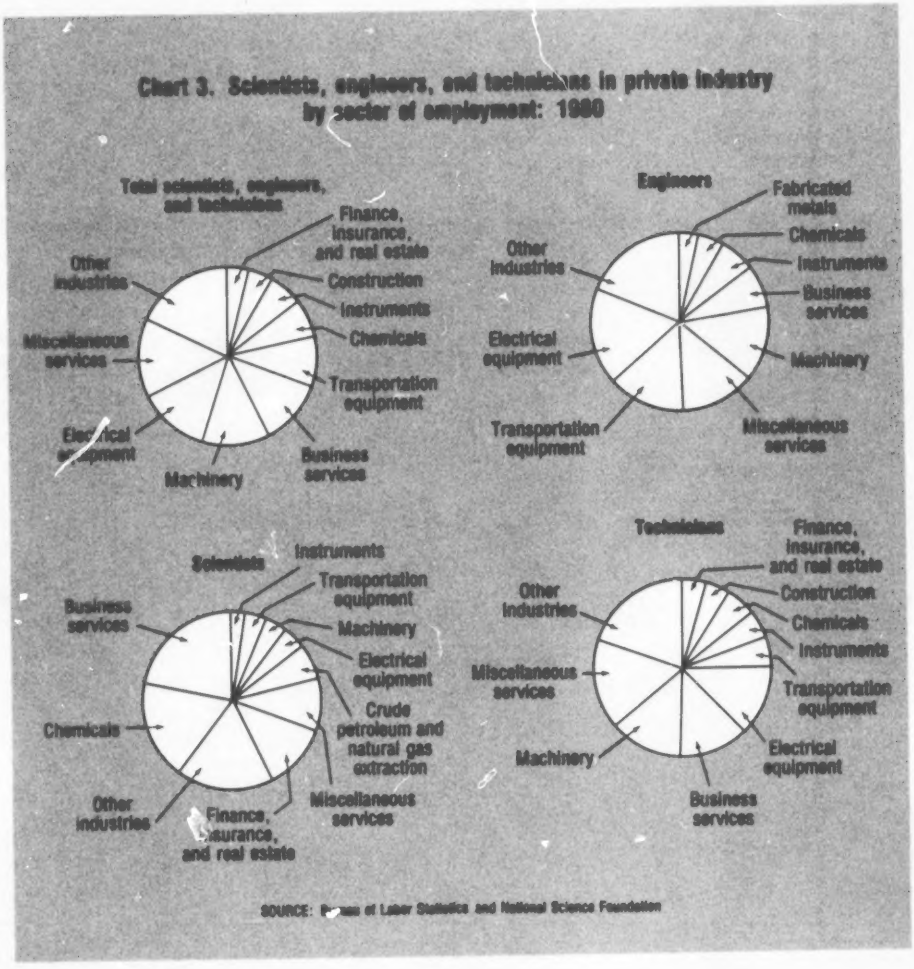


Chart 2. Percent growth of scientist and engineer employment in private industry
By selected sectors: 1978-80
-2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 19 20
Manufacturing, Total
Primary metals
Fabricated metals
Machinery
Electrical equipment
Transportation equipment
Professional & scientific instruments
Chemicals and allied products
Petroleum refining
Nonmanufacturing, Total
Crude petroleum & natural gas extraction
Other mining
Construction
Finance, insurance, and real estate
Business services
Miscellaneous services
SOURCE: Bureau of Labor Statistics and National Science Foundation

employment by industry

Manufacturing Industries

Of the estimated 2.1 million scientists, engineers, and technicians employed in private industry in January 1980, the manufacturing sector is estimated to have employed over 1.25 million, 69 percent of industrial engineers, 45 percent of industrial scientists, and 55 percent of industrial technicians (table 1). Within this sector, major employers were the electrical equipment industry; machinery, transportation equipment; and chemicals. The largest employer of engineers was the electrical equipment industry; the chemicals industry employed the most scientists; and the machinery industry employed the largest number of technicians (chart 3).



Nonmanufacturing Industries[3]

Nonmanufacturing industries are estimated to have employed about 860,000 scientists, engineers, and technicians in January 1980, or 41 percent of private industry employment. Engineering employment was estimated at around 255,000, employment of scientists at about 155,000, and employment of technicians at about 450,000. Major employing industries within this sector were: miscellaneous services; business services;[4] for total SE&T employment; (miscellaneous services; business services); and construction for engineers; business services; miscellaneous services; and crude petroleum and natural gas extraction (for scientists); and miscellaneous services and business services (for technicians).

[3] Excludes trade and regulated industries (communications, transportation, and public utilities). The estimates for 1980 are based on extrapolation of survey data for 1978 for the nonmanufacturing sector and 1977 for the manufacturing sector.

[4] Miscellaneous services include such activities as engineering, architectural, and surveying services; noncommercial educational, scientific and research organizations; accounting, auditing, and bookkeeping services; and services, not elsewhere classified. Business services include computer and data processing services, including programming services; research and development laboratories; management and consulting services and commercial testing laboratories.

Table 1: Estimated employment of scientists, engineers, and technicians in private industry[1] by sector and occupational group: January 1980

[Thousands]

Industry	Scientists, engineers, and technicians, total		Scientists and engineers						Technicians	
			Total		Engineers		Scientists			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	2,113	100.0	1,110	100.0	824	100.0	286	100.0	1,004	100.0
Manufacturing	1,251	59.2	697	62.8	567	68.8	130	45.4	554	55.2
Durable goods	985	46.6	544	49.0	489	59.3	54	18.9	443	44.1
Primary metals	44	2.1	24	2.2	20	2.4	4	1.5	20	2.0
Fabricated metals	71	3.3	35	3.1	31	3.7	4	1.3	36	3.6
Machinery	255	12.1	121	10.9	110	13.4	11	4.0	134	13.3
Electrical equipment	275	13.0	158	14.2	146	17.7	12	4.3	117	11.6
Transportation equipment	186	8.8	127	11.4	115	14.6	11	4.0	59	5.9
Instruments	120	5.7	62	5.6	55	6.6	7	2.6	58	5.8
All other durable goods	36	1.7	16	1.4	12	1.5	4	1.4	20	2.0
Nondurable goods	266	12.6	154	13.9	78	9.5	76	26.5	112	11.1
Chemicals	147	6.9	90	8.1	39	4.7	52	18.1	56	5.6
Petroleum refining	26	1.2	18	1.6	11	1.3	7	2.3	9	.9
All other nondurable goods	93	4.4	46	4.2	29	3.5	17	6.0	47	4.7
Nonmanufacturing	862	40.8	413	37.2	257	31.2	156	54.6	449	44.8
Crude petroleum and natural gas extraction	55	2.6	37	3.3	18	2.2	19	6.5	18	1.8
Other mining	18	.8	11	1.0	7	.9	4	1.3	7	.7
Construction	96	4.5	51	4.6	49	6.0	1	.5	45	4.5
Finance, insurance and real estate	85	4.0	41	3.7	6	.7	35	12.1	44	4.4
Business services	253	12.0	125	11.2	62	7.6	62	21.7	129	12.8
Miscellaneous services	305	14.4	139	12.5	111	13.5	27	9.5	166	16.5
All other services	51	2.4	11	1.0	2	.3	9	3.0	40	4.0

[1] Excluding trade, communications, transportation and public utilities.

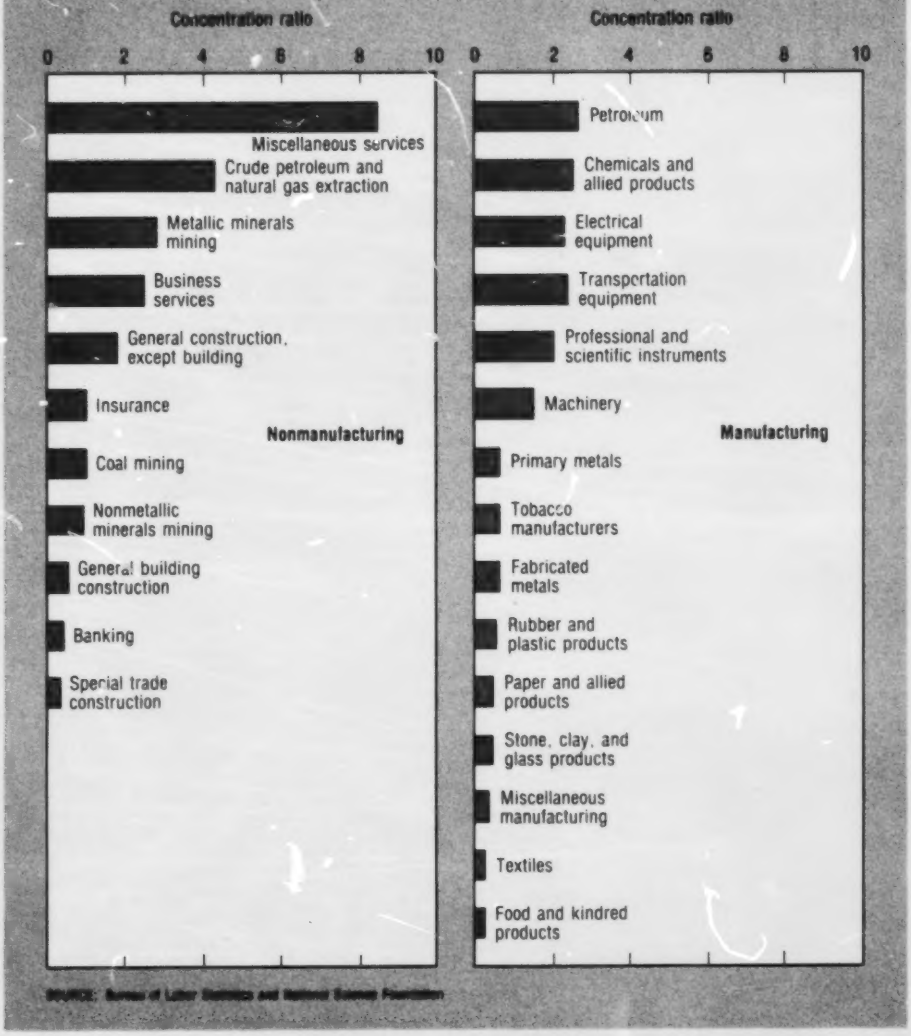
Source: National Science Foundation

concentration and technological intensity

Employment of scientists, engineers, and technicians in these industries is not widely dispersed. Of the 17 industries examined, the four biggest employed over one-half of the total scientists, engineers and technicians: miscellaneous services, 14 percent; electrical equipment, 13 percent; machinery and business services, each 12 percent (chart 3 and table 1). By broad occupational groups, the major employing industries for engineers are: electrical equipment industry, transportation equipment, miscellaneous services, and machinery each employing 13 percent to 18 percent of the total. Scientists are highly concentrated in two industries—business services, 22 percent, and chemicals, 18 percent. The concentration of scientists in these industries results from the heavy utilization of computer scientists in the former and chemists in the latter.

The concentration of scientists and engineers in a relatively small number of industries is the result of either the concentration of industrial activity in these industries, or the fact that their industrial technology requires a relatively large number of employees with S/E skills. One way to determine the relative effect of these two determinants on the industrial distribution of scientists and engineers is to develop a "concen-

Chart 4. Concentration ratios of scientists and engineers by industry: 1980



SOURCE: Bureau of Labor Statistics and National Science Foundation

tration ratio" for each industry, relating that industry's share of S/E[5] employment to its share of total (i.e., S/E and non-S/E) employment. A ratio close to unity for the industries which were large employers implies that the large S/E employment is primarily the result of large amounts of industrial activity (reflected by total employment). A ratio greater than unity implies that these industries are relatively technologically intensive.

[5] Because of the wide range of technological skill attributes of "technicians" as defined in this report, the technological intensity ratios are limited to an examination of the relative concentrations of scientists and engineers. For derivation of the concentration ratio, see the technical notes.

Regarded another way, the concentration ratio is a means of decomposing two effects on the employment of scientists and engineers in an industry: the scale effect, resulting from the level of production, and the effect of differing technology in producing each industry's output. Applying this type of analysis to the industrial employment distribution of scientists, engineers, and technicians, we find that the concentration of the four industries cited above is primarily due to high technology intensity. The same conclusion holds if one narrows the focus to only scientists and engineers.

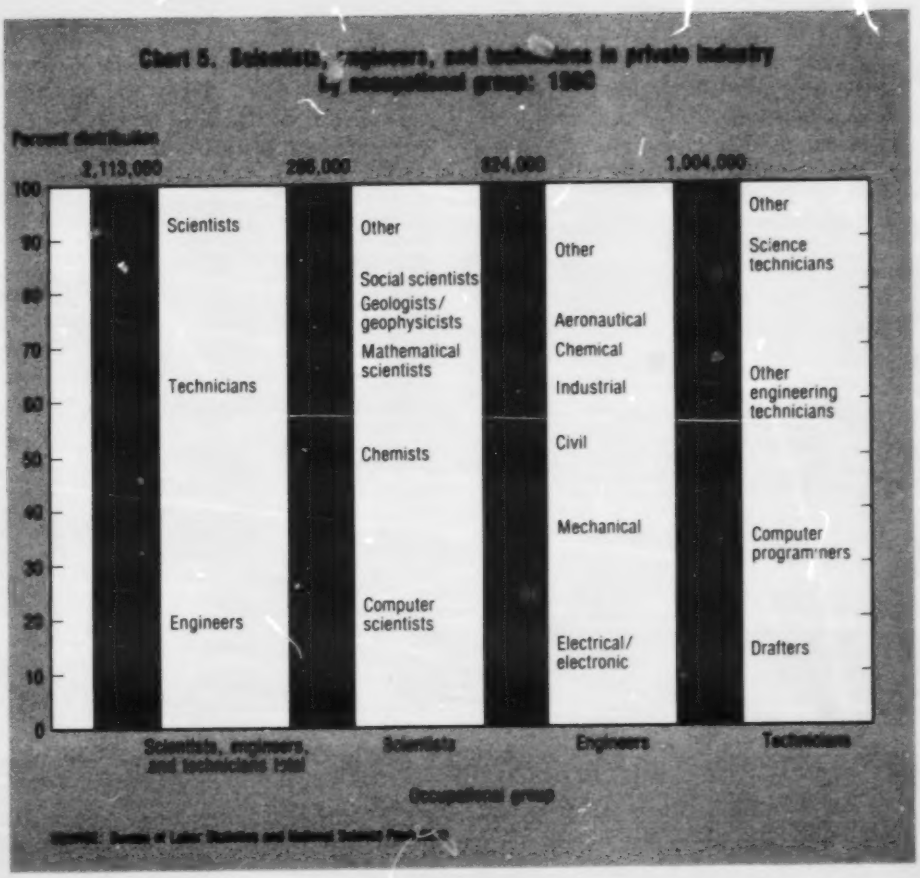
Continuing our focus on scientists and engineers, we find that, among the nonmanufacturing industries, the miscellaneous services industry had the most technologically concentrated work force, employing almost nine times the number of scientists and engineers expected, judged by its share of total nonmanufacturing employment (chart 4). Other highly concentrated nonmanufacturing industries were crude petroleum and natural gas extraction, 4.3; metallic minerals mining, 2.8; business services, 2.5; and general construction, except building, 1.8. In the manufacturing sector, petroleum refining and chemicals and allied products had the greatest concentration of scientists and engineers—2.6 and 2.5, respectively.

employment by occupation

Within the industries examined, engineers outnumber scientists by almost 3 to 1 (chart 5). Engineers are more heavily utilized in manufacturing, while scientists are more intensively utilized in nonmanufacturing industries (table 1). Technicians are more equally distributed between these two sectors.

Within manufacturing, the largest engineering specialty is electrical/electronic, followed by mechanical engineers. The predominance of these two specialities reflects the large number of electrical engineers in the electrical equipment manufacturing industry and the employment of relatively large numbers of mechanical engineers in the machinery industry. Within nonmanufacturing, civil engineers predominate, reflecting the large numbers employed in engineering and architectural services firms.

Chemists make up the largest science specialty in manufacturing industries and computer system analysts predominate in the nonmanufacturing sector. Each accounts for about 45 percent of all scientists in their respective sectors. Within



nonmanufacturing, computer specialists are concentrated in the service sector, primarily business services. Most of the remaining scientists in nonmanufacturing are physical scientists, primarily geologists and geophysicists employed in the petroleum and natural gas industry.

Through the seventies, total employment in nonmanufacturing industries increased more rapidly than in manufacturing, and long-range projections indicate that these trends will continue at least through the mideighties.[6] Assuming no radical shifts in the occupational distributions within these industries, the relative shift from manufacturing to nonmanufacturing industries that has occurred and is expected to continue in the United States has important implications for the demand for scientists, engineers, and technicians by specialty. The major beneficiaries of this shifting pattern of industrial growth have been and will be those specialities with high concentrations in the nonmanufacturing sector—civil engineers, computer specialtists, and geologists and geophysicists. They will probably continue to enjoy above-average rates of employment growth in the industries examined.

Radical shifts in future occupational distributions within these industries caused either by technological changes and/or dramatic shifts in the relative costs of employing these specialties could alter the projected employment outlook. It should also be remembered that these implications are based only on the employment patterns found in the industries examined in this report. The employment implications for specialties that have relative employment concentrations in other sectors of the economy where growth has been less rapid than in the industrial sector are more pessimistic—for example, in the academic sector where employment growth has been tapering off and is expected to continue to grow slowly because of demographic factors. Most of the science specialties (with the exception of computer scientists and possibly chemists and geologists and geophysicists) are concentrated in the academic sector.

Table 2: Ratio of scientists and engineers to technicians in private industry by selected sector: 1980

Industry	Ratio
Total, private industry	1.11
Manufacturing, total	1.25
Primary metals	1.22
Fabricated metals	.96
Machinery	.91
Electrical equipment	1.35
Transportation equipment	2.13
Instruments	1.06
All other durable goods	.81
Chemicals	1.61
Petroleum refining	2.04
All other nondurable goods	.99
Nonmanufacturing	.92
Crude petroleum and natural gas extraction	2.08
Other mining	1.61
Construction	1.11
Finance, insurance and real estate	.92
Business services	.97
Miscellaneous services	.83
All other services	.27

Source: Bureau of Labor Statistics and National Science Foundation

The ratio of scientists and engineers to technicians can be used as an index of the "skill intensity" of SE&T employment. Technicians are generally less skilled and are used directly or indirectly to support scientists and engineers in every phase of their work. The skill intensity index for the private sector was 0.90 in 1978, showing that for every 100 scientists and engineers, there were 90 technicians, and varies widely among industries (table 2), ranging from 0.27 in the least skill-intensive industry, all other services, to 2.13 in the most skill-intensive industry, transportation equipment. On average, manufacturing industries are more skill-intensive in their utilization of scientists, engineers, and technicians than nonmanufacturing industries. Within manufacturing, in addition to the transportation equipment industry, the chemical and the petroleum refining industries were relatively skill-intensive users of scientists, engineers, and technicians. Within nonmanufacturing, the industries that perform crude petroleum and natural gas extraction and "other" (i.e., nonmetal and noncoal) mining activities were highly skill-intensive. The wide variation in skill intensity among industries summarized in table 2 is the result of several factors including: the technology of the industry; and the substitutability of technicians with other occupations including scientists and engineers, and the relative costs of scientists and engineers versus technicians.

[6] Projections for 1985 are based on unpublished data of BLS. Trends in aggregate employment by industry were generated by BLS as part of their ongoing program for studying alternative patterns of economic growth. See U.S. Department of Labor, Bureau of Labor Statistics, *Handbook of Methods for Surveys and Studies*, Bulletin 1910, 1976 and *Employment Projections for the 1980's*, *Bulletin 2030*, 1979 (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office).

appendixes

A. Technical Notes
B. Statistical Tables

appendix a

technical notes

General

The national estimates of employment in scientific, technical, and engineering occupations in nonmanufacturing industries are based on data from the 1978 Occupational Employment Statistics (OES) Nonmanufacturing Industries survey. The OES programs is a Federal-State cooperative effort which enables States to conduct their own surveys to produce State estimates. The Bureau of Labor Statistics (BLS) provides survey procedures, technical guidance, and assistance with problems. The cooperating State agencies are the State Employment Security Agencies. Forty-three of the 50 States (51 including the District of Columbia) cooperated in the OES program at the time of the nonmanufacturing industries survey. A supplemental survey, funded in part by the National Science Foundation, was conducted in the eight noncooperating States by BLS in order to provide national estimates. All estimation was done by BLS.

Scope of Survey

The survey covered private nonmanufacturing establishments in Standard Industrial Classification (SIC) codes 10–17, 60–67, 72, 73, 75, 76, 78, 79, 80, 81, 83, 84, 86, and 89. The reference date of the survey[1] was the week that included April 12, May 12, or June 12, 1978, depending on the SIC of the sampled unit as shown at right.

[1]The survey reference date is the date for which employment data were requested from respondents.

Geographically, the survey covered all 50 States plus the District of Columbia.

Method of Collection

The survey schedules were initially mailed to most sample establishments while personal visits were made for some larger companies.

Two additional mailings were made to nonrespondents at approximately 6-week intervals. Telephone followup and in some cases personal visit followups were made for those nonrespondents considered (because of size) critical to the survey.

Sampling Procedure

The sampling frame for this survey was the list of units in the specified SIC's as reported in the State Unemployment Insurance (UI) files (excluding government units). Because each cooperating State selected its own sample, the reference date of the sampling frame[2] varied according to when the last updates to the frame were made and when sampling

[2]The sampling frame reference date refers to the date at which the UI files were most recently validated and updated.

Industry	SIC	Reference Date
Metal mining	10	May 12
Bituminous coal mining	11	May 12
Anthracite coal mining	12	May 12
Crude petroleum and natural gas extraction	13	May 12
Nonmetallic minerals mining	14	May 12
General building construction	15	June 12
General construction, except building	16	June 12
Special trade contractors	17	June 12
Banking	60	June 12
Credit agencies other than banks	61	May 12
Security, commodity, etc. brokers	62	June 12
Insurance	63	May 12
Insurance brokers	64	May 12
Real estate	65	May 12
Combination real estate, law insurance	66	May 12
Holding and investment companies	67	June 12
Hotels	70	May 12
Other personal services	72	May 12
Business services	73	June 12
Auto repairs	75	May 12
Other repairs	76	June 12
Theaters	78	April 12
Miscellaneous entertainment	79	April 12
Medical services	80	May 12
Legal services	81	June 12
Social services	83	May 12
Museums	84	April 12
Nonprofit membership organizations	86	April 12
Miscellaneous services	89	June 12

took place. The reference date for the frame used for sampling in the eight supplemental States was the first quarter of 1977.

The universe was stratified into SIC and size classes. The size classes were determined by employment as follows:

Size Class	Employees
1	1–3
2	4–9
3	10–19
4	20–49
5	50–99
6	100–249
7	250–499
8	500–999
9	1000+

State Samples

UI reporting units with three or fewer employees were not sampled in all States, but units with four to nine employees were given larger weights to represent the employment in the smaller size class. UI reporting units with 250 or more employees were included in the sample with certainty. For noncertainty size classes a sample size intended to produce State estimates with target relative errors of between 10 percent and 15 percent at one standard deviation was developed. This was done for groups of SIC's based on analysis for employment distributions by occupation and coefficients of variation (CV's) from the previous survey for a set of typical occupations. This sample size determined for the noncertainty portion of each SIC industry was allocated to the size classes within that SIC proportional to employment in each size class. The sample was selected systematically with equal probability within each State/SIC/size-class cell.

National Supplement Sample

The sample size for the eight supplemental States was developed by first determining the sample size required for national estimates in each 2-digit SIC with a target relative error of 15 percent at one standard deviation. This was done by analyzing CV's and employment distributions by occupation for a set of scientific, technical, and engineering occupations from the previous survey. This national SIC sample size for the noncertainty segment was then allocated to the noncooperating States/size-class cells proportional to employment in each cell. Establishments with 1,000 or more employees were included with certainty. The above allocations resulted in a total initial sample size for all States of 333,115 reporting units.

Response

There were 321,916 final eligible units in the sample (i.e., excluding out-of-business, out-of-scope, etc.). Usable responses were obtained from 214,686 units, producing an overall response rate of 66.7 percent based on units and 62.9 percent based on employment. Subsequent to the national estimates, additional data were received by States and used in preparing States estimates. Response rates in most States were significantly higher than the response rate used to develop national estimates.

Estimation

A weight was determined for each sample unit from which a usable response was received. Each weight was composed of two factors. The first factor was the inverse of the probability of selection. For questionnaires that were not returned or otherwise not usable, a nonresponse adjustment was made to correct for these nonrespondents. For each of the 3-digit/SIC/size-class sampling cells, a nonresponse factor was calculated that was equal to:

$$\frac{\text{Weighted sample employment of all eligible units in sample}}{\text{Weighted sample employment of all responding eligible units}}$$

The sample employments were taken from the sampling frame. If the factor in a cell was greater than a predetermined maximum factor (based on previous survey experience) which increased as the number of respondents in a cell increased, the cell was collapsed with other homogeneous cells within the SIC until the factor for the combined cells was not greater than the appropriate maximum factor. For size classes one through six, homogeneous cells were determined to be other size cells within the SIC and State. For size classes seven through nine, homogenous cells were determined to be other State cells within the SIC and size. The weight for each establishment was the product of the two factors.

If the collapsing procedure terminated (i.e., no more cells were available for collapse) before satisfying the above constraint, then the appropriate maximum factor was used.

A combined ratio estimate of occupational employment was used to develop the national estimates. The auxiliary variable used was total employment.

The estimating formula is:

$$\hat{p} = \sum_i \left[\frac{\sum_j \sum_k W_{ijk} P_{ijk}}{\sum_j \sum_k W_{ijk} e_{ijk}} \right] M_i$$

where

$\hat{p}$ = 2-digit industry occupational employment estimate

i = 3-digit industry within a 2-digit industry

j = size class

k = establishment

W_{ijk} = weight after nonresponse adjustment

P_{ijk} = occupational employment in i^{th} industry, j^{th} size class and k^{th} establishment

e_{ijk} = total employment in the i^{th} industry, j^{th} size class and k^{th} establishment

M_i = benchmark total employment in i^{th} industry

The population value of total employment (M_i) was obtained from the BLS Survey of Employment, Hours and Earnings.

The standard form for the sampling variance for a combined ratio estimate is.[3]

$$V(\hat{p}) = \sum_i \sum_j \frac{N_{ij}^2 (1-f_{ij})}{n_{ij}} (S^2_{p_{ij}} + R_i^2 S^2_{e_{ij}} - 2R_i S_{p_{ij}, e_{ij}})$$

where

$V(\hat{p})$ = variance of $\hat{p}$

i = 3-digit industry within a 2-digit industry

j = size class

[3] This formula is derived from the equation for computing the variance of a ratio estimate given in *Sampling Techniques* by William Cochran (New York: John Wiley and Sons, 1977), p. 166.

N_{ij} = total number of units in the i^{th} industry and j^{th} size class

f_{ij} = sampling fraction in the i^{th} industry and j^{th} size class

n_{ij} = number of sample units in the i^{th} industry and j^{th} size class

$R_i = \frac{\sum_j \sum_k W_{ijk} P_{ijk}}{\sum_j \sum_k W_{ijk} e_{ijk}}$

S_{pij} = standard deviation of p within the i^{th} industry and j^{th} size class

S_{eij} = standard deviation of e within the i^{th} industry and j^{th} size class

P_{ij} = correlation coefficient between p and e within the i^{th} industry and j^{th} size class

The variances for the occupational estimates were estimated using the following formula.

$$Var(\bar{p}) = \sum_i \sum_j T_{ij} V_{ij}^2 \quad \text{where}$$

$$T_{ij} = \left[\frac{M_{ij} - e_{ij}}{M_{ij}}\right] \left[\frac{(\sum_k W^2_{ijk})(\sum_k W_{ijk})}{(\sum_k W_{ijk})^2 - (\sum_k W^2_{ijk})}\right] \left[\frac{M_i}{\sum_j \sum_k W_{ijk} e_{ijk}}\right]^2 \quad \text{and}$$

$$V^2_{ij} = \sum_k W_{ijk} \left(P_{ijk} - P_i e_{ijk}\right) - \left(P_{ij} - R_i e_{ij}\right)]^2$$

where

M_{ij} = benchmark total employment in the i^{th} industry and j^{th} size class

$e_{ij} = \sum_k e_{ijk}$

All other terms are as defined above. This formula is almost a computational form of the standard formula given above. One simplifying assumption has been made. This assumption is:

$W_{ijk} = c_{ij}$ for all k in a given ij cell

That is, the weights are equal to a constant c within a given 3-digit industry/size cell. At this time, the total effect of this assumption on the variance estimates has not been measured.

Reliability of Estimates

There are two types of errors, sampling and nonsampling, possible in estimates, such as those reported here, which are based on a sample survey. Sampling errors occur because observations are made only on a sample, not on the entire population. Nonsampling errors can be attributed to many sources, e.g., inability to obtain information about all cases in the sample, differences in the respondents' interpretation of questions, inability of respondents to provide correct information, errors made in recording, coding, or processing the data, errors made in estimating values for missing data, failure to represent adequately all units in the population, etc.

The particular sample selected is one of a large number of samples of the same type and size that, by chance, might have been selected. Estimates from each of the different samples would differ somewhat from each other, and from the results of a complete canvass conducted under essentially the same conditions as the survey. This variation among the possible estimates is defined by the sample error, measured in standard error units. The complete canvass total would be included in the range—

(1) From one standard error below to one standard error above the derived estimate for 68 percent of all samples.

(2) From two standard errors below to two standard errors above the derived estimate for 95 percent of all samples.

(3) From three standard errors below to three standard errors above the derived estimate for nearly all samples.

An inference that the comparable complete canvass total would be within the indicated ranges would be correct in approximately the relative frequencies shown. Those proportions indicated in previous items (1), (2), and (3), therefore, may be interpreted as defining the confidence that the estimates from a particular sample would differ from complete coverage results by as much as one, two, or three standard errors, respectively.

For example, suppose an estimated total is shown as 5,000 with an associated standard error of 100. There is a 68-percent chance that the complete coverage total would be between 4,900 and 5,100 and it is almost certain that the complete coverage total would be between 4,700 and 5,300. The relative error of this estimate is (100/5,000) = .02, or 2 percent.

These relative errors indicate the magnitude of the sampling error. Efforts were made to reduce the biases because of errors in recording, coding, and processing the data. The adjustments made for nonrespondents assumed that the characteristics of the nonrespondents were the same as those of the respondents.

Particular care should be exercised in the interpretation of small estimates, estimates based on a small number of cases, or small differences between estimates because of relatively large sampling errors of these estimates.

Table B-4 presents relative errors of the estimates resulting from this survey. The relative error is defined as the standard error divided by the estimated value expressed as a percentage of the estimated value.

Current Employment Estimates

Based on the assumption that the skill-mix within industry changes relatively slowly over a short period of time,[4] it is possible to use the results of the 1977 and 1978 OES surveys for estimating changes in scientist, engineer, and technician (SE&T) requirements without surveying the sectors each year. By applying the

[4]Department of Labor, Bureau of Labor Statistics, *Tommorrow's Manpower Needs: Research Report on Manpower Projection Methods*, Bulletin 1769 (Washington, D.C., 1973). This report concludes that about one-half the change in occupational employment in the 10-year period 1960–70 is accounted for by changes in industry employment. If the change in skill-mix is assumed to occur at a constant rate, and if the change for SE&T occupations is assumed to occur at the same rate as for those occupations reported on in the study, a method incorporating only the change in industrial mix will account for 95 percent of the change in SE&T occupational employment when using industrial employment data one year removed from the base period. Given these assumptions, the analysis reported in the text is probably within 8 percent of the actual change in SE&T employment in nonmanufacturing for the period between the OES survey date (April, May, and June of 1978) and January 1980, and within 13 percent of the actual change in manufacturing between 1977 and January 1980.

percentage distribution of the occupational mix in the base period to current estimates of industry employment,[5] updated estimates of occupational employment may be obtained. For example, according to the 1978 OES survey, in the miscellaneous services industry civil engineers were 4.9 percent of total employment. Since total employment in this industry grew 10.7 percent from the date of the survey to January 1980, the assumption of constant occupational shares implies that employment of civil engineers in this industry also increased 10.7 percent from 42,800 to 47,400 in that period.

Expanding this procedure to the entire nonmanufacturing sector, it is estimated that in January 1980 employment of scientists, engineers, and technicians was about 9.6 percent higher than at the survey date. Engineering employment is estimated to have increased 8.7 percent; employment of scientists increased by 10.7 percent; and technician employment increased by about 11 percent. The validity of the assumptions underlying the foregoing analysis cannot be empirically validated until comparable data for 1980 become available.

By using data from the previous 1977 OES survey of manufacturing industries and applying the same method, it is also possible to generate estimates of employment in the manufacturing sector for the same time periods. These estimates show that total SE&T employment grew 4.5 percent from 1978 to January 1980, less than half as fast as the growth in nonmanufacturing. Engineers in this sector grew at a 4.6 percent rate, scientists at 2.6 percent, and technicians at 4.8 percent. The growth in this sector was considerably greater in the durable goods producing industries (5.4 percent for all scientists, engineers, and technicians) than in nondurable goods industries (1.1 percent).

Definition of Scientists, Engineers, and Technicians

"Scientists" includes persons concerned with research in science or in the application of scientific laws and principles to specific situations, engaged in work which requires a knowledge of the field equivalent to that acquired through completion of a 4-year college course with a major in the specific field, and who spend the major proportion of their time in such activity. "Engineers" includes persons concerned with the practical application of physical laws and principles of engineering for the development and utilization of machines, materials, instruments, processes, and services, engaged in such work at a level which requires knowledge of engineering at least equivalent to that acquired through the completion of a 4-year college course with a major in one of the engineering fields, and who spend the major proportion of their time in such activity. "Technicians" includes persons usually working under the direction of a scientist or engineer, who assist the former in the application of engineering or scientific laws and principles, or in research.

Concentration Ratios

The "concentration ratios" shown in this report are defined as follows:

$$C_i = (S_i / S.) / (E_i / E.),$$

where C_i is the concentration ratio for industry i, S_i is the number of scientists and engineers in industry i, S. is the total number of scientists and engineers in the sector (manufacturing or nonmanufacturing), E_i is the total employment in industry i and E. is the total employment in nonmanufacturing. The concentration ratios shown are based on the 1978 estimated employment mix in nonmanufacturing and the 1977 employment mix in the manufacturing sector.

[5] Department of Labor, Bureau of Labor Statistics, *Employment and Earnings* (monthly) (Washington, D.C.: Supt. of Documents, U.S. Government Printing Office.)

appendix b

STATISTICAL TABLES

		Page
B-1	Employment of scientists, engineers, and technicians in nonmanufacturing industries: 1978	17
B-2	Employment distribution of scientists, engineers, and technicians in nonmanufacturing industries by industry (percent): 1978	20
B-3	Employment distribution of scientists and engineers in nonmanufacturing industries by occupation (percent): 1978	23
B-4	Relative error (in percent) of estimated employment of scientists, engineers, and technicians in nonmanufacturing industries by industry and detailed occupation: 1978	25

Table B-1. Employment of scientists, engineers, and technicians in nonmanufacturing industries: 1978

Industry	Total scientists, engineers, and technicians	Total scientists and engineers	Engineers							
			Total	Aero/ astro-nautical	Chemical	Civil	Electrical/ electronic	Indus-trial	Mechan-ical	Metal-lurgi-cal
Total nonmanufacturing	793.4	379.1	236.4	5.1	9.5	65.8	49.9	7.1	45.8	2.7
Mining	62.7	41.3	22.3	0	.8	1.1	1.3	.5	1.2	.5
Metal mining	6.8	4.4	2.2	0	'	.1	0	.2	.2	.4
Coal mining	6.8	4.2	3.5	0	0	.2	0	.2	.1	'
Crude petroleum, natural gas	45.8	30.8	15.4	0	.7	.7	1.3	0	.7	0
Nonmetalic mining	3.3	1.3	1.2	0	.1	.1	0	.1	.1	.1
Construction	95.9	51.5	50.0	0	0	18.8	7.6	0	13.4	0
General building	21.9	10.8	10.5	0	0	5.3	.6	0	2.0	0
General except building	43.7	28.6	27.5	0	0	9.1	4.4	0	6.7	0
Special trade	30.3	12.1	12.1	0	0	4.4	2.6	0	4.6	0
Finance, insurance, real estate	80.0	38.3	5.8	0	.1	0	0	0	0	.1
Banking and other credit	24.1	10.2	.4	0	0	0	0	0	0	0
Insurance	40.5	19.9	2.8	0	.1	0	0	0	0	.1
Other finance, insurance, real estate	15.3	8.1	2.4	0	0	0	0	0	0	0
Services	554.7	248.0	158.3	5.1	8.6	45.9	40.9	6.6	31.3	2.2
Business services	225.1	110.4	55.5	3.8	4.7	3.0	21.7	3.6	10.2	1.5
Repairs, except auto	17.2	.3	.3	0	0	0	.2	0	.1	0
Miscellaneous services	284.8	127.3	100.6	1.3	3.9	42.8	18.9	3.0	21.0	.8
Other services	25.1	10.2	2.2	0	0	.1	.1	.1	.1	0

Industry	Engineers				Scientists					
	Mining	Petro-leum	Safety	All other	Total	Physical	Chemists	Geolo-gists/ geophys.	Oceanog-raphers	Physi-cists
Total nonmanufacturing	3.3	11.3	4.3	31.6	142.7	36.7	10.0	18.7	.4	4.6
Mining	3.1	9.8	1.7	2.4	19.0	15.8	1.5	14.0	0	0
Metal mining	.8	0	.2	.3	2.2	2.0	.4	1.6	0	0
Coal mining	1.5	0	.9	.5	.7	.5	.2	.2	0	0
Crude petroleum, natural gas	.3	9.8	.4	1.5	15.5	12.7	.6	12.0	0	0
Nonmetalic mining	.4	0	.1	.1	.6	.6	.2	.3	0	0
Construction	0	0	1.6	8.7	1.5	0	0	0	0	0
General building	0	0	.5	2.0	.3	0	0	0	0	0
General except building	0	0	1.1	6.2	1.1	0	0	0	0	0
Special trade	0	0	'	.5	'	0	0	0	0	0
Finance, insurance, real estate	0	0	'	5.6	32.5	.7	0	.6	0	0
Banking and other credit	0	0	0	.4	9.8	'	0	0	0	0
Insurance	0	0	0	2.8	17.0	.1	0	0	0	0
Other finance, insurance, real estate	0	0	'	2.4	5.7	.6	0	.6	0	0
Services	.3	1.5	1.0	14.9	89.7	20.1	8.5	4.1	.4	4.6
Business services	0	.8	.6	5.7	54.9	12.8	6.4	1.4	.1	3.7
Repairs, except auto	0	0	0	.1	(1)	0	0	0	0	0
Miscellaneous services	.3	.7	.4	7.7	26.7	7.3	1.9	2.7	.3	1.0
Other services	0	0	0	1.5	8.0	.4	.3	0	0	0

Table B-1—Continued

Industry	Scientists								
	Other physical	Total life	Agricultural	Biological	Other life	Total mathematical	Mathematicians	Statisticians	Other mathematical
Total nonmanufacturing	2.9	9.7	.6	2.4	6.2	18.7	3.6	7.8	7.4
Mining	.4	0	0	0	0	.6	.5	0	0
Metal mining	.1	0	0	0	0	0	0	0	0
Coal mining	0	0	0	0	0	.1	0	0	.1
Crude petroleum, natural gas	.2	0	0	0	0	.5	.5	0	0
Nonmetalic mining	.1	0	0	0	0	[1]	0	0	0
Construction	0	0	0	0	0	0	0	0	0
General building	0	0	0	0	0	0	0	0	0
General except building	0	0	0	0	0	0	0	0	0
Special trade	0	0	0	0	0	0	0	0	0
Finance, insurance, real estate	.1	[1]	[1]	0	0	8.3	0	3.1	5.2
Banking and other credit	[1]	0	0	0	0	.2	0	0	.2
Insurance	.1	0	0	0	0	6.0	0	1.9	4.1
Other finance, insurance, real estate	[1]	[1]	[1]	0	0	2.1	0	1.2	.9
Services	2.4	9.6	.6	2.4	6.2	9.7	3.0	4.6	2.1
Business services	.9	3.0	.6	1.9	.5	4.2	2.1	2.0	.1
Repairs, except auto	0	0	0	0	0	[1]	0	0	[1]
Miscellaneous services	1.4	5.7	0	0	5.7	3.5	1.0	.6	2.0
Other services	.1	.6	[1]	.4	[1]	2.0	0	2.0	0

Industry	Scientists						Technicians			
	Total social	Economists	Psychologists	Sociologists	Other social	Computer systems analysts	Total technicians	Total engineering	Drafters	Electrical/ electronic
Total nonmanufacturing	13.9	4.3	5.6	1.4	2.5	64.1	414.3	279.9	131.1	59.5
Mining	0	0	0	0	0	2.5	21.4	14.5	5.6	1.1
Metal mining	0	0	0	0	0	.1	2.4	1.2	.4	0
Coal mining	0	0	0	0	0	.2	2.6	1.9	.8	0
Crude petroleum, natural gas	0	0	0	0	0	2.2	14.9	10.8	4.2	1.1
Nonmetalic mining	0	0	0	0	0	[1]	1.5	.5	.2	0
Construction	0	0	0	0	0	1.5	44.4	40.6	21.8	12.4
General building	0	0	0	0	0	.3	11.1	9.9	7.8	.5
General except building	0	0	0	0	0	1.1	15.1	13.1	8.1	.3
Special trade	0	0	0	0	0	[1]	18.2	17.7	5.9	11.6
Finance, insurance, real estate	1.3	1.2	0	0	.2	22.2	41.7	2.4	.9	0
Banking and other credit	.9	.7	0	0	.2	8.6	13.9	.2	0	0
Insurance	.2	.2	0	0	0	10.8	20.6	.5	.2	0
Other finance, insurance, real estate	.2	.2	0	0	0	2.7	7.2	1.8	.7	0
Services	12.6	3.2	5.6	1.4	2.4	38.0	306.7	223.3	102.8	46.1
Business services	4.7	2.2	1.6	1.0	.5	30.6	114.7	53.6	18.3	22.8
Repairs, except auto	0	0	0	0	0	0	16.9	16.6	.5	15.9
Miscellaneous services	2.8	.8	1.0	0	2.0	6.4	157.5	143.5	83.4	6.1
Other services	4.1	1.0	3.1	.5	.4	1.0	17.6	8.6	.6	1.2

Table B-1—Continued

Industry	Technicians								
	Surveyors	Mechanical	Specification writers	Civil engineering	Other engineering	Total science	Biological	Other science	Computer programmer
Total nonmanufacturing	33.2	4.4	1.3	21.2	29.2	20.9	3.5	17.4	81.2
Mining	1.7	0	0	0	6.2	3.2	0	3.2	1.9
Metal mining	.4	0	0	0	.4	.7	0	.7	.2
Coal mining	.7	0	0	0	.4	.2	0	.2	.2
Crude petroleum, natural gas	.5	0	0	0	5.0	1.6	0	1.6	1.5
Nonmetalic mining	.1	0	0	0	.2	.7	0	.7	.1
Construction	3.6	0	0	0	2.8	0	0	0	1.4
General building	.9	0	0	0	.6	0	0	0	.5
General except building	2.7	0	0	[illegible]	2.0	0	0	0	.8
Special trade	[1]	0	0	0	.2	0	0	0	.1
Finance, insurance, real estate	.3	0	0	0	1.2	0	0	0	27.9
Banking and other credit	0	0	0	0	.2	0	0	0	9.5
Insurance	.1	0	0	0	.1	0	0	0	15.1
Other finance, insurance, real estate	.2	0	0	0	.9	0	0	0	3.3
Services	27.6	4.4	1.3	21.2	18.9	17.7	3.5	14.2	49.9
Business services	.7	4.4	0	0	7.4	12.4	0	12.4	40.6
Repairs, except auto	0	0	0	0	.1	0	0	0	[1]
Miscellaneous services	24.3	0	1.3	21.2	7.1	4.4	3.3	1.1	6.4
Other services	2.7	0	0	0	4.1	.9	.1	.7	2.9

Industry	Technicians
	All other
Total nonmanufacturing	35.1
Mining	1.8
Metal mining	.3
Coal mining	.2
Crude petroleum, natural gas	1.1
Nonmetalic mining	.2
Construction	2.3
General building	.8
General except building	1.1
Special trade	.4
Finance, insurance, real estate	111.3
Banking and other credit	4.2
Insurance	5.0
Other finance, insurance, real estate	2.2
Services	19.6
Business services	8.0
Repairs, except auto	.3
Miscellaneous services	3.2
Other services	8.1

[1] Less than 50.
Note: Parts may not add to totals because of rounding.
Source: Bureau of Labor Statistics and National Science Foundation

Table B-2. Employment distribution of scientists, engineers, and technicians in nonmanufacturing industries (Percent)

Industry	Total scientists, engineers, and technicians	Total scientists and engineers	Engineers							
			Total	Aero/ astro-nautical	Chemical	Civil	Electrical/ electronic	Indus-trial	Mechan-ical	Metal lurgi-cal
Total nonmanufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mining	8.0	10.9	9.4	0	8.8	1.7	2.6	6.5	2.5	16.8
Metal mining	.9	1.2	.9	0	.5	.2	0	2.3	.5	13.1
Coal mining	.9	1.1	1.5	0	0	.3	0	2.7	.2	1.5
Crude petroleum, natural gas	5.8	8.2	6.5	0	6.9	1.1	2.6	0	1.5	0
Nonmetalic mining	.4	.5	.5	0	1.4	.2	0	1.5	.3	2.2
Construction	12.2	13.6	21.2	0	0	28.5	15.3	0	29.2	0
General building	2.8	2.9	4.4	0	0	8.1	1.2	0	4.4	0
General except building	5.5	7.6	11.6	0	0	13.8	8.8	0	14.6	0
Special trade	3.9	3.2	5.1	0	0	6.6	5.3	0	10.1	0
Finance, insurance, real estate	10.2	10.1	2.4	0	.7	0	0	0	0	2.4
Banking and other credit	3.0	2.7	.2	0	0	0	0	0	0	0
Insurance	5.1	5.3	1.2	0	.7	0	0	0	0	2.4
Other finance, insurance, real estate	2.0	2.2	1.0	0	0	0	0	0	0	0
Services	69.7	65.3	67.0	100.0	90.5	69.8	82.1	93.5	68.3	80.6
Business services	28.7	29.4	23.5	74.6	49.8	4.5	43.5	50.8	22.3	53.0
Repairs, except auto	2.2	.1	.1	0	0	0	.3	0	.1	0
Miscellaneous services	35.0	33.2	42.6	25.4	40.7	65.0	37.8	41.8	45.8	27.8
Other services	3.8	7.6	.7	0	0	.2	.4	.9	.1	0

Industry	Engineers				Scientists					
	Mining	Petro-leum	Safety	All other	Total	Physical	Chemists	Geolo-gists/ geophys.	Oceanog-raphers	Physi-cists
Total nonmanufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mining	92.5	87.1	39.0	7.7	13.5	43.1	14.7	74.7	0	0
Metal mining	24.4	0	5.5	.9	1.6	5.5	4.3	8.30	0	0
Coal mining	46.6	0	22.0	1.6	.5	1.2	2.3	.9	0	0
Crude petroleum, natural gas	9.9	87.1	9.2	4.8	11.0	34.8	5.6	64.2	0	0
Nonmetalic mining	11.5	0	2.3	.4	.4	1.6	2.4	1.3	0	0
Construction	0	0	37.2	27.4	1.0	0	0	0	0	0
General building	0	0	10.8	6.4	.2	0	0	0	0	0
General except building	0	0	25.9	19.5	.8	0	0	0	0	0
Special trade	0	0	.5	1.4	0	0	0	0	0	0
Finance, insurance, real estate	0	0	.1	17.8	23.1	2.0	0	3.4	0	0
Banking and other credit	0	0	0	1.5	7.0	0	0	0	0	0
Insurance	0	0	0	8.7	12.1	.2	0	0	0	0
Other finance, insurance, real estate	0	0	.1	7.5	4.1	1.7	0	3.4	0	0
Services	7.5	12.9	23.7	47.2	62.4	54.9	85.3	22.0	100.0	100.0
Business services	0	6.7	13.2	18.0	39.2	33.9	63.8	7.4	26.8	78.9
Repairs, except auto	0	0	0	.2	1	0	0	0	0	0
Miscellaneous services	7.5	6.2	10.5	24.3	17.5	19.9	19.0	14.6	73.2	20.8
Other services	0	0	0	4.5	5.6	2.2	2.6	0	0	.3

Table B-2—Continued

Industry	Scientists								
	Other physical	Total life	Agri-cultural	Bio-logical	Other life	Total mathe-matical	Mathe-maticians	Statis-ticians	Other mathe-matical
Total nonmanufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mining	13.0	0	0	0	0	3.4	17.4	0	0
Metal mining	1.8	0	0	0	0	.1	.5	0	0
Coal mining	2.1	0	0	0	0	.4	2.0	0	0
Crude petroleum, natural gas	5.9	0	0	0	0	2.9	14.6	0	0
Nonmetalic mining	3.1	0	0	0	0	.1	.3	0	0
Construction	0	0	0	0	0	0	0	0	0
General building	0	0	0	0	0	0	0	0	0
General except building	0	0	0	0	0	0	0	0	0
Special trade	0	0	0	0	0	0	0	0	0
Finance, insurance, real estate	3.1	.1	2.2	0	0	44.5	0	40.4	71.4
Banking and other credit	.1	0	0	0	0	1.0	0	0	2.7
Insurance	2.3	0	0	0	0	32.0	0	24.8	56.0
Other finance, insurance, real estate	.6	.1	2.2	0	0	7.1	0	15.7	12.8
Services	84.0	99.9	97.8	100.0	100.0	52.1	82.6	59.6	28.6
Business services	29.9	35.2	95.3	79.6	7.8	22.5	56.8	26.2	1.3
Repairs, except auto	0	0	0	0	0	1	0	0	.1
Miscellaneous services	48.6	58.7	0	0	91.1	18.8	25.8	7.6	27.2
Other services	5.4	5.9	2.5	20.4	1.1	10.7	0	25.7	0

Industry	Scientists						Technicians			
	Total social	Economists	Psychol-ogists	Sociol-ogists	Other social	Computer systems analysts	Total technicians	Total engi-neering	Drafters	Electrical/ electronic
Total nonmanufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mining	0	0	0	0	0	4.0	5.2	5.2	4.3	1.8
Metal mining	0	0	0	0	0	.2	.6	.4	.3	0
Coal mining	0	0	0	0	0	.3	.6	.7	.6	0
Crude petroleum, natural gas	0	0	0	0	0	3.4	3.6	3.8	3.2	1.8
Nonmetalic mining	0	0	0	0	0	1	.4	.2	.2	0
Construction	0	0	0	0	0	2.3	10.8	14.5	16.6	20.8
General building	0	0	0	0	0	.5	2.7	3.5	6.0	.8
General except building	0	0	0	0	0	1.7	3.7	4.7	6.2	.6
Special trade	0	0	0	0	0	.1	4.4	6.3	4.5	19.4
Finance, insurance, real estate	11.1	27.0	0	0	27.5	34.5	10.2	.9	.7	0
Banking and other credit	7.6	17.9	0	0	27.5	13.5	3.4	.1	0	0
Insurance	1.7	4.7	0	0	0	16.8	5.0	.2	.2	0
Other finance, insurance, real estate	1.6	4.4	0	0	0	4.2	1.8	.6	.5	0
Services	88.9	73.0	100.0	100.0	72.5	59.2	73.7	79.4	78.4	77.4
Business services	39.3	49.8	27.9	67.6	0	47.7	28.0	19.2	14.0	38.3
Repairs, except auto	0	0	0	0	0	1	4.1	5.9	.4	26.7
Miscellaneous services	15.3	18.5	18.2	0	0	9.9	36.6	51.3	63.6	10.3
Other services	34.2	4.6	53.9	32.4	72.5	1.5	9.0	3.0	.5	2.1

Table B-2—Continued

Industry	Technicians									
	Surveyors	Mechanical engineering	Specification writers	Civil engineering	Oil exploration	Other engineering	Total science	Biological	Other science	Computer programmers
Total nonmanufacturing	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mining	5.0	0	0	0	72.0	20.3	19.5	0	19.7	2.4
Metal mining	1.1	0	0	0	0	.6	3.9	0	4.0	.2
Coal mining	2.1	0	0	0	0	1.6	1.4	0	1.5	.2
Crude petroleum, natural gas	1.5	0	0	0	72.0	16.5	9.7	0	9.8	1.8
Nonmetalic mining	.3	0	0	0	0	.7	4.4	0	4.4	.1
Construction	10.9	0	0	0	0	9.9	0	0	0	1.8
General building	2.8	0	0	0	0	2.2	0	0	0	.6
General except building	8.0	0	0	0	0	7.0	0	0	0	1.0
Special trade	.1	0	0	0	0	.7	0	0	0	.2
Finance, insurance, real estate	.8	0	0	0	0	4.3	0	0	0	34.4
Banking and other credit	0	0	0	0	0	.8	0	0	0	11.6
Insurance	.2	0	0	0	0	.5	0	0	0	18.6
Other finance, insurance, real estate	.6	0	0	0	0	3.1	0	0	0	4.0
Services	83.3	100.0	100.0	100.0	28.0	65.5	80.5	100.0	80.3	61.5
Business services	2.1	100.0	0	0	0	26.0	75.3	0	76.0	50.0
Repairs, except auto	0	0	0	0	0	.5	0	0	0	[1]
Miscellaneous services	73.1	0	100.0	100.0	28.0	24.6	0	0	0	7.9
Other services	8.0	0	0	0	0	14.5	5.3	100.0	4.4	3.4

Industry	Technicians
	All other
Total nonmanufacturing	100.0
Mining	5.7
Metal mining	.9
Coal mining	.7
Crude petroleum, natural gas	3.4
Nonmetalic mining	.6
Construction	7.3
General building	2.5
General except building	3.6
Special trade	1.3
Finance, insurance, real estate	35.4
Banking and other credit	13.2
Insurance	15.6
Other finance, insurance, real estate	6.6
Services	51.5
Business services	25.2
Repairs, except auto	1.0
Miscellaneous. services	0
Other services	25.4

[1] Less than .005 percent.

Note: Parts may not add to totals because of rounding.

Source: Bureau of Labor Statistics and National Science Foundation

Table B-3. Employment distribution of scientists and engineers in nonmanufacturing industries by occupation (Percent)

Industry	Total scientists and engineers	Total engineers	Engineers						
			Aero/ astro-nautical	Chemical	Civil	Electrical/ electronic	Indus-trial	Mechan-ical	Metal-lurgi-cal
Total nonmanufacturing	100.0	62.8	1.4	2.5	17.4	13.2	1.9	12.1	.7
Mining	100.0	54.0	0	2.0	2.7	3.1	1.1	2.8	1.1
Metal mining	100.0	50.3	0	1.1	2.3	0	3.7	5.4	8.1
Coal mining	100.0	83.2	0	0	4.6	0	4.6	2.6	.9
Crude petroleum, natural gas	100.0	49.8	0	2.1	2.3	4.2	0	2.2	0
Nonmetalic mining	100.0	65.3	0	7.5	6.5	0	5.9	7.7	3.3
Construction	100.0	97.2	0	0	36.5	14.8	0	25.9	0
General building	100.0	97.1	0	0	49.5	5.6	0	18.9	0
General except building	100.0	96.1	0	0	31.8	15.4	0	23.5	0
Special trade	100.0	99.6	0	0	35.9	21.7	0	38.1	0
Finance, insurance, real estate	100.0	15.0	.2	0	0	0	0	0	.2
Banking and other credit	100.0	3.9	0	0	0	0	0	0	0
Insurance	100.0	14.5	0	.3	0	0	0	0	.3
Other finance, insurance, real estate	100.0	29.6	0	0	0	0	0	0	0
Services	100.0	64.2	2.1	3.5	18.6	16.6	2.7	12.7	.9
Business services	100.0	50.1	3.4	4.3	2.7	19.6	3.2	9.2	1.3
Repairs, except auto	100.0	96.8	0	0	0	55.0	0	16.2	0
Miscellaneous services	100.0	80.3	1.0	3.1	34.2	15.1	2.4	16.7	.6
Other services	100.0	21.6	0	0	.0	1.0	1.0	1.0	0

Industry	Engineers					Scientists				
	Mining	Petro-leum	Safety	All other	Total	Physical	Chemists	Geolo-gists/ geophys.	Oceanog-raphers	Physi-cists
Total nonmanufacturing	.9	3.0	1.1	8.4	37.4	9.7	2.7	5.0	.1	1.2
Mining	7.4	23.8	4.0	5.9	46.0	38.3	3.6	33.8	0	0
Metal mining	18.3	0	5.3	6.2	49.7	45.9	9.8	35.0	0	0
Coal mining	36.5	0	22.2	11.8	16.8	10.8	5.5	3.8	0	0
Crude petroleum, natural gas	1.1	31.8	1.3	4.9	50.2	41.3	1.8	38.9	0	0
Nonmetalic mining	21.5	0	5.6	7.2	34.7	32.7	13.6	14.1	0	0
Construction	0	0	3.1	16.8	2.8	0	0	0	0	0
General building	0	0	4.3	18.8	2.9	0	0	0	0	0
General except building	0	0	3.9	21.6	3.9	0	0	0	0	0
Special trade	0	0	.2	3.8	.4	0	0	0	0	0
Finance, insurance, real estate	0	0	[illegible]	14.7	85.0	1.9	0	1.6	0	0
Banking and other credit	0	0	0	3.9	96.1	0	0	0	0	0
Insurance	0	0	0	13.9	85.5	.3	0	0	0	0
Other finance, insurance, real estate	0	0	0	29.6	70.4	7.4	0	7.4	0	0
Services	.1	.6	.4	6.1	3[illegible].8	8.2	3.5	1.7	.2	1.9
Business services	0	.7	.5	5.2	49.9	11.2	5.8	1.3	.1	3.3
Repairs, except auto	0	0	0	25.6	3.2	0	0	0	0	0
Miscellaneous services	.2	.6	.4	6.1	19.7	5.8	1.5	2.2	.2	.8
Other services	0	0	0	14.7	78.4	39.9	2.9	0	0	0

Table B-3—Continued

Industry	Scientists								
	Other physical	Total life	Agri-cultural	Bio-logical	Other life	Total mathe-matical	Mathe-maticians	Statis-ticians	Other mathe-matical
Total nonmanufacturing	.8	2.6	.2	.6	1.6	5.0	1.0	2.1	1.9
Mining	9	0	0	0	0	1.6	1.6	0	0
Metal mining	1.2	0	0	0	0	.5	.5	0	0
Coal mining	1.5	0	0	0	0	1.7	1.7	0	0
Crude petroleum, natural gas	.6	0	0	0	0	1.7	1.7	0	0
Nonmetalic mining	5.1	0	0	0	0	.6	.6	0	0
Construction	0	0	0	0	0	0	0	0	0
General building	0	0	0	0	0	0	0	0	0
General except building	0	0	0	0	0	0	0	0	0
Special trade	0	0	0	0	0	0	0	0	0
Finance, insurance, real estate	.2	[1]	[1]	0	0	21.8	0	6.2	13.6
Banking and other credit	[1]	0	0	0	0	2.0	0	0	2.0
Insurance	.3	0	0	0	0	30.1	0	9.6	20.4
Other finance, insurance, real estate	0	0	0	0	0	25.9	0	14.8	11.1
Services	1.0	3.9	.3	1.0	2.5	4.0	1.2	1.9	.8
Business services	.8	3.1	.6	1.7	.4	3.8	1.9	1.8	.1
Repairs, except auto	0	0	0	0	0	1.9	0	0	1.9
Miscellaneous services	1.1	4.5	0	0	4.5	2.8	.8	.5	1.6
Other services	1.0	5.9	0	3.9	0	19.6	0	19.6	0

Industry	Scientists					
	Total social	Economists	Psychol-ogists	Sociol-ogists	Other social	Computer systems analysts
Total nonmanufacturing	3.2	1.2	1.5	.4	.1	17.0
Mining	0	0	0	0	0	6.2
Metal mining	0	0	0	0	0	3.3
Coal mining	0	0	0	0	0	4.2
Crude petroleum, natural gas	0	0	0	0	0	7.1
Nonmetalic mining	0	0	0	0	0	1.5
Construction	0	0	0	0	0	2.8
General building	0	0	0	0	0	2.9
General except building	0	0	0	0	0	3.9
Special trade	0	0	0	0	0	.4
Finance, insurance, real estate	3.5	3.1	0	0	.4	57.8
Banking and other credit	8.8	6.9	0	0	2.0	84.3
Insurance	1.0	1.0	0	0	0	54.0
Other finance, insurance, real estate	2.5	2.5	0	0	0	33.3
Services	4.3	1.3	2.3	.6	.2	15.4
Business services	4.2	2.0	1.4	.9	0	27.6
Repairs, except auto	0	0	0	0	0	1.3
Miscellaneous services	1.5	.6	.8	0	0	5.1
Other services	40.2	9.8	30.4	4.9	3.9	9.8

[1] Less than .005 percent.

Note: Parts may not add to totals because of rounding.

Source: Bureau of Labor Statistics and National Science Foundation

Table B-4. Relative error as percent of estimated employment of scientists, engineers, and technicians in nonmanufacturing industries by industry and detailed occupation: 1978[1]

Industry	Total scientists, engineers, and technicians	Total scientists and engineers	Engineers							
			Total	Aero/ astro-nautical	Chemical	Civil	Electrical/ electronic	Indus-trial	Mechan-ical	Metal-lurgi-cal
Total nonmanufacturing	12	14	13	29	15	6	14	21	14	23
Mining	15	14	14		25	16	43	12	23	6
Metal mining	7	7	5		18	6		7	5	3
Coal mining	17	17	14			17		18	39	62
Crude petroleum, natural gas	16	14	15		26	17	43		27	
Nonmetalic mining	16	17	14		23	14		11	13	15
Construction	15	16	16			10	24		18	
General building	11	11	11			7	18		16	
General except building	22	22	22			13	33		26	
Special trade	9	8	8			7	10		6	
Finance, insurance, real estate	17	17	20							
Banking and other credit	13	14	22							
Insurance	14	14	15							
Other finance, insurance, real estate	29	26	26							
Services	11	13	11	29	14	4	12	21	10	27
Business services	15	18	19	31	18	23	15	26	15	29
Repairs, except auto	7	45	45				26		88	
Miscellaneous services	6	8	6	25	11	3	6	14	5	24
Other services	24	17	41			36	81	61	103	

Industry	Engineers				Scientists					
	Mining	Petro-leum	Safety	All other	Total	Physical	Chemists	Geolo-gists/ geophys.	Oceanog-raphers	Physi-cists
Total nonmanufacturing	17	11	18	19	16	17	17	6	32	25
Mining	15	8	10	17	15	12	26	9		
Metal mining	4		3	6	9	9	6	9		
Coal mining	13		9	20	30	27	19	34		
Crude petroleum, natural gas	59	8	14	18	14	11	47	9		
Nonmetalic mining	12		11	23	24	24	10	26		
Construction			14	20						
General building			12	14	16					
General except building			17	22	24					
Special trade				23						
Finance, insurance, real estate				20	16	64		67		
Banking and other credit				22	14					
Insurance				15	14	50				
Other finance, insurance, real estate				26	26	67		67		
Services	34	27	40	18	16	20	16	18	32	25
Business services		28	46	24	18	23	16	29	45	27
Repairs, except auto				40						
Miscellaneous services	34	25	32	11	14	15	14	12	28	18
Other services				52	14	33	28			

Table B-4—Continued

Industry	Scientists								
	Other physical	Total life	Agri-cultural	Bio-logical	Other life	Total mathe-matical	Mathe-maticians	Statis-ticians	Other mathe-matical
Total nonmanufacturing	30	23	49	29	17	20	25	22	16
Mining	39					42	40		52
Metal mining	16								
Coal mining						52			52
Crude petroleum, natural gas	48					40	40		
Nonmetalic mining	46								
Construction									
General building									
General except building									
Special trade									
Finance, insurance, real estate	50					20		29	14
Banking and other credit						12			12
Insurance	50					18		33	12
Other finance, insurance, real estate						24		22	26
Services	28	23		29	17	19	23	17	18
Business services	40	38	49	28	64	24	24	21	81
Repairs, except auto									
Miscellaneous services	19	12			12	18	21	22	15
Other services	41	34		32	38	11		11	

Industry	Scientists						Technicians			
	Total social	Economists	Psychol-ogists	Sociol-ogists	Other social	Computer systems analysts	Total technicians	Total engi-neering	Drafters	Electrical/ electronic
Total nonmanufacturing	27	28	18	48	39	11	11	10	6	10
Mining						27	17	16	11	35
Metal mining						7	7	6	7	
Coal mining						28	17	15	18	
Crude petroleum, natural gas						28	19	17	9	35
Nonmetalic mining							14	12	12	
Construction						22	15	13	14	10
General building						16	11	10	7	43
General except building						24	23	23	27	24
Special trade						80	10	8	7	9
Finance, insurance, real estate	22	20			37	12	16	28	19	
Banking and other credit	20	15			37	13	12	25		
Insurance	24	24				11	14	31	25	
Other finance, insurance, real estate	31	31				18	32	28	17	
Services	27	30	18	48	39	9	9	9	4	9
Business services	45	34	33	58	103	8	12	15	12	10
Repairs, except auto							7	6	9	6
Miscellaneous services	19	18	19		19	10	5	5	2	9
Other services										

Table B-4—Continued

Industry	Technicians								
	Surveyors	Mechanical	Specification writers	Civil engineering	Other engineering	Total science	Biological	Other science	Computer programmers
Total nonmanufacturing	14	20	13	5	22	17	17	17	9
Mining	15				17	16		18	19
Metal mining	5				7	7			13
Coal mining	10				19	22		23	26
Crude petroleum, natural gas	31				18	21		21	18
Nonmetalic mining	11				13	11		11	18
Construction	10				23	35			21
General building	11				23				12
General except building	9				24				26
Special trade					42	35			35
Finance, insurance, real estate	35				33				11
Banking and other credit					25				7
Insurance	46				29				12
Other finance, insurance, real estate	29				36				14
Services	15	20	13	5	22	17	17	11	7
Business services	54	20			28	17		17	6
Repairs, except auto					44				
Miscellaneous services	9		13	5	10	15	15	15	10
Other services	50				34	51	52	51	17

Industry	Technicians
	All other
Total nonmanufacturing	25
Mining	26
Metal mining	5
Coal mining	23
Crude petroleum, natural gas	32
Nonmetallic mining	32
Construction	31
General building	24
General except building	19
Special trade	79
Finance, insurance, real estate	29
Banking and other credit	25
Insurance	18
Other finance, insurance, real estate	61
Services	22
Business services	15
Repairs, except auto	23
Miscellaneous services	12
Other services	32

[1] Empty cells indicate that no employment estimates were available.
Source: Bureau of Labor Statistics and National Science Foundation

other science resources publications

Science Resources Studies Highlights

R&D Expenditures

	NSF No.	Price
"March Cutback in Federal Budget Leaves Strong Defense R&D Growth in 1981—Other Areas Lag"	80-319	—
"National R&D Spending Expected to Reach $67 Billion in 1981"	80-310	—
"Federal Obligations to Universities and Colleges Continued Real Growth in FY 1978"	80-303	—
"Doctoral Institutions Report 6% Real Increase in R&D Expenditures in FY 1978"	80-301	—
"Greatest Increase in 1978 Industrial R&D Expenditures Provided by 14% Rise in Companies' Own Funds"	80-300	—

S/E Personnel

"Academic Employment of Scientists and Engineers Increased 4% in Doctorate Institutions in FY 1979"	80-309	—
"Employment of Scientists and Engineers Increased Between 1976 and 1978 But Declined in Some Science Fields"	80-305	—
"Decline in Recent Science and Engineering Doctoral Faculty Continues into 1978"	79-301	—

Detailed Statistical Tables

R&D Expenditures

Federal Funds for Research and Development, Fiscal Years 1979, 1980, and 1981	80-318	—
Research and Development in Industry, 1978	80-307	—
Research and Development in State and Local Governments, Fiscal Year 1977	79-327	—
Academic Science: R&D Funds, Fiscal Year 1978	79-320	—

S/E Personnel

Scientists and Engineers From Abroad, 1976-78	80-324	—
Characteristics of Doctoral Scientists and Engineers in the United States, 1979	80-323	—
"Academic Science: Graduate Enrollment and Support, Fall 1979"	80-321	—
U.S. Scientists and Engineers, 1978	80-304	—
Academic Science: Scientists and Engineers, January 1979	79-328	—
Characteristics of Experienced Scientists and Engineers, 1978	79-322	—

Reports

R&D Expenditures

Federal Funds for Research and Development, Fiscal Years 1978, 1979, and 1980, Volume XXVIII	80-315	$3.75
Federal Support to Universities, Colleges, and Selected Nonprofit Institutions, Fiscal Year 1978	80-312	$5.50

S/E Personnel

Occupational Mobility of Scientists and Engineers	80-317	$1.75
Science and Engineering Personnel: A National Overview	80-316	$4.25
Employment Patterns of Academic Scientists and Engineers, 1973-78	80-314	$1.75
Projections of Science and Engineering Doctorate Supply and Utilization, 1982 and 1987	79-303	$2.25

Composite

Academic Science, 1972-77: R&D Funds, Scientists and Engineers, and Graduate Enrollment and Support	80-313	$4.25
National Patterns of Science and Technology Resources, 1980	80-308	$3.75

Reviews of Data on Science Resources

R&D Expenditures

No. 35, "State and Local Government R&D Expenditures, FY 1977"	80-302	$1.25
No. 33, U.S. Industrial R&D Spending Abroad"	79-304	$0.70

S/E Personnel

No. 36, "Employment Characteristics of Recent Science and Engineering Graduates: The Effects of Work Experience, Advanced Degrees, and Business Cycles"	80-311	$1.50
No. 34, "Sex and Ethnic Differentials in Employment and Salaries Among Federal Scientists and Engineers"	79-323	$1.00